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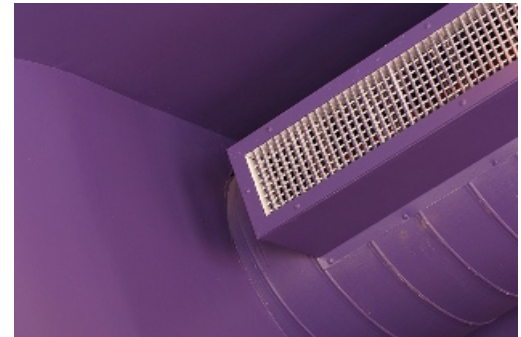
## Design & Construction Techniques

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### From Residential to Light Commercial Building—a Focus on HVAC

By J.F. McCarthy

The housing downturn has caused successful residential builders to seek new project opportunities in the commercial sector. Although a first commercial project in a hospital or manufacturing building may be too large a step, a single-story retail or office project can be feasible, if key differences between residential and commercial are understood. HVAC differences are discussed below, so builders can avoid common mistakes and maximize potential success.



#### HVAC system requirements for both residential and commercial

All residential and commercial buildings occupied by people (not warehouses and storage buildings) have similar HVAC requirements.

##### *Heating and cooling*

Mechanical heating is provided either by electrical resistance coils, expansion of refrigerant (such as a heat pump), or combustion of fuel. Cooling is typically by direct expansion of gases in a coil, with heat discharged through an air-cooled condenser.

##### *Ventilation*

All systems require fresh air, general exhaust, toilet exhaust, and process exhaust consisting of kitchen and other fume hoods. Systems that heat by combustion also require provision of combustion makeup air and discharge of flue gases.

##### *Distribution and zone control*

Forced air distribution usually uses a low-pressure sheet metal ductwork distribution system. Dampers within the ductwork and at the grilles provide limited zone control and adjustments. Larger buildings require more zone control—ranging from interior and exterior zones up to a zone for very room.

##### *Power and control wiring*

Power wiring includes over current protection, fusing, and a disconnect for safe servicing. Supplemental convenience power is also frequently required for the safety of the servicing personnel.

Control of the mechanical system components and zone control devices was formerly pneumatic, but new installations are usually low-voltage systems.

#### How we meet these requirements in residential construction

##### *Mechanical heating and cooling, windows for most ventilation*

Residential construction relies on operable windows to satisfy outside air, general exhaust toilet exhaust, and sometimes kitchen exhaust ventilation requirements. Exhaust fans are added for toilets with no windows,

and frequently kitchens.

The mechanical units sizing is done solely by calculating heating and cooling loads. One or more units of up to about 3 tons are selected, and each unit has a single zone. A common sense duct layout provides limited zone control.

*Power wiring is single-phase and easily achieved*

Service disconnects for single-phase power are little more complicated or expensive than a light switch.



### **How we meet these requirements in light commercial construction**

Commercial construction does not rely on windows for ventilation. The outside air, general exhaust, toilet exhaust, and process exhaust must be specifically calculated and provided by the mechanical systems. So in addition to the heating and cooling calculation used in residential construction, heating and cooling of the newly introduced outside air must be added. This fundamental difference changes the selection and installation of all mechanical components.

### **Common light commercial systems**

*Rooftop units heat and cool, and provide outside air*

Rooftop mechanical units provide the heating and cooling requirements and most ventilation requirements, and are the workhorse of light commercial construction. A rooftop unit is a factory "catalog made to order" assembly that includes a condenser and an expansion coil for cooling, a heat source and a single fan for forced air heating, and an intake opening for outside air. The fuel heat flue discharges on the side of the unit.

*Power wiring starts to get more complicated and expensive*

Units up to 3 tons can be 120v, 208v, or 240v. The most common units of 7-15 tons and larger units can be 208v, 240v or 480v.

Power is supplied to a disconnect mounted on the side of the unit. Frequently a 120-volt convenience receptacle for use by the service personnel is either included with the unit or installed in the field. A disconnect on the larger units can become custom order and expensive. And for the largest units, breakers in the panel alone are not enough, and alteration to the electrical service gear for the entire building is required.

*Outside air improvement, power exhaust*

Outside air control can be improved with an "economizer." This is a modulating damper that senses the outside air temperature, and increases the intake air to up to 100% to provide free cooling when possible. Power exhaust can be, but seldom is, added as an option to a rooftop unit. Independent general and toilet exhaust systems are usually more cost effective. But this then requires a barometric relief valve on the rooftop unit, so outside air injected by the system does not excessively pressurize the building.

*Zone control is added*

Commercial buildings with a larger spaces, more rooms, and unevenly located windows (which have a greater heating and cooling load) make zone control more important.

In the small—say 1,500 square feet—strip shopping center spaces, there is a single zone, and forced air zoning is ignored. If multiple spaces are joined for a single tenant, the ductwork from each single zone rooftop unit can be configured to provide interior and exterior zones.

The next level of improvement is adding zone control devices in the ductwork. Here, the unit discharges air at a specified temperature, and zone dampers in the ductwork modulate the air volume for temperature control in 6 to about 12 zones. Each mechanical unit must have a bypass damper to short-circuit the supply air to the return to relieve pressure when many dampers restrict airflow at once. It also requires a system controller to coordinate the unit and devices.

In colder climates, radiant heating near the windows and in the vestibule is frequently added to supplement the heating in these zones. Electric reheats in the ducts were formerly used for economic zone control. But energy conservation codes are increasingly restricting or prohibiting these coils to avoid cooling and then

reheating the same air.

## **Common errors and how to avoid them**

### *Don't use residential systems for commercial projects*

A common error is to place residential HVAC systems in commercial buildings. These systems are not designed for or capable of providing the code-required outside air. Homemade additions of outside air ducts may work on paper and fool the inspectors sufficiently to get a permit. However, nonfunctional outside air intakes filled with spider webs and bird's nests will produce a stuffy lower-grade building.

### *Outside air intakes must be included when ordering the rooftop unit*

Rooftop units without outside air intakes are suitable for cooling for a warehouse, but not an occupied building.

### *Don't forget general exhaust*

The necessary and code-required exhaust can be provided in any of the ways described above. Choose one, and include appropriate compensating features, such as a barometric relief valve, so the whole HVAC system works together.

### *Roof alterations are trickier, can be costly, and must be managed*

Increasingly, commercial flat roofs are proprietary systems that specify exactly how each roof curb and penetration must be configured to maintain the warranty. Since curbs and roofing are both set on the deck, the curb height must include the thickness of the roofing with insulation and the required height above the top of the roofing. If the roof slopes more than 2% (1/4" in 1') the curb must be altered to keep the top level.

Also, proper portals to accommodate the control wiring, power wiring, and gas piping must be used. Simply poking through and caulking with roofing cement has no place in this type of construction. Roofing patches must be done by a factory-certified technical, so arrangements must be made and costs included.

### *Roof structure must be considered also*

Metal roof structures are designed for little additional load, so additional rooftop units may require structural reinforcing. A common solution is to place the new rooftop unit with the compressor (heavy end) over a beam. Angle iron reinforcing in the joist web also may be required. In some municipalities, any additional structural work must be designed by a structural engineer or architect.

### *Zoning is important for customer satisfaction*

The opportunities for zoning in the smallest of commercial structures are limited, as described above. However, some measures and some attempt must be made, or the customer may think the building just doesn't work.

### *Disconnects become more costly and tricky to order*

For the smallest rooftops, disconnects are similar to residential. However as the unit size increases, the cost of disconnects increases faster. Disconnects must be specifically selected for their characteristics as disconnects and over-current protection, and quickly can cost 1 to 5 weeks' wages. Either the electrical or the HVAC contractor can provide them, but they must be purchased correctly once and only once.

### *Missing the service receptacle*

A 120-volt service receptacle is generally advisable—and frequently code-required—on each rooftop unit. Purchase this as an option on the unit, or field install it at the time of rooftop installation. Adding the receptacle when its absence is noticed at final inspection means more time and money.

### *More technical knowhow, with some certification required*

As described above, ordering the rooftop units becomes a more complicated task requiring thinking through the entire building system, not just the rooftop unit itself. Using the key points described above can assist in achieving satisfactory results. However, a hasty order can mean the only solution is to tear off the roof unit and buy a new one.

Also, for some mechanical systems such as zone and temperature control, factory certification of the installer is required. This can be as simple as a seminar provided free by the factory. So it is easily achievable, but only if you plan ahead.

**This applies only to buildings about two stories high—higher buildings are different**

The pointers itemized above will greatly assist the residential contractor in a successful transition to commercial work. But these pointers apply only to buildings of about two stories. Although the basic principles are the same for larger buildings, the systems' configurations are completely different. Instead of the rooftop unit, the HVAC systems are custom designed using multiple components, and different and more sophisticated control and building automation system systems are added.

Some of these systems and approaches are discussed in our recent book *Choosing Project Success: A Guide for Building Professionals*, at [www.paretobi.com](http://www.paretobi.com). The caution produced by knowing that the next step is a big one, and that even a small-tenant project in a high-rise building will be governed by different rules, can avoid a big and costly mistake, and keep your transition to commercial work successful.

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